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THE EARLY HISTORY OF UROLOGY *

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WE rarely find that the name and designation of a branch of medicine bears as little relation to its content, concept, and extent, as is the case in urology. For the original meaning of the word urology gives no inkling that it applies to one of the most important special fields of medicine, one that not only comprises the knowledge of the entire internal and external pathology and therapy of the urinary apparatus, but also touches neighboring fields and indeed extends directly into their domain. Nevertheless, the word urology is clearly indicative that the entire modern development of this branch of science, with its complicated methods and remarkable achievements, derives in the last analysis from the simple uroscopy as we find it practiced in the most remote periods by physicians of all peoples. In casting a backward glance upon the early history of urology, we must bear in mind that the ancients used the inspection of the urine, its taste and smell, principally in order to draw conclusions as to the general state of health of the entire body, and did not attach much importance to uroscopy in purely local diseases.

Leaving aside the interesting references to urine diagnosis contained in Babylonian, Egyptian, and Indian medicine, we shall begin with water-casting in the time of Hippocrates, whose writings contain an abundance of relevant material. The technique of uroscopy even at that early period had attained a high degree of excellence, although the methods did not concern themselves so much with the diagnosis of individual diseases as with the progress or course of disease in general. The Hippocratic writers, however, describe in an excellent manner several morbid affections of the urinary apparatus, laying particular stress on the color of the urine and on urinary sediment. They distin-

* "Aus der Vergangenheit der Urologie," *Wiener klinische Wochenschrift*, 1936, Nr. 37/38. This translation is printed by kind permission of the author and of the publishers of the *Wiener klinische Wochenschrift*.

guish various kinds of sediment according to color, general appearance, quantity and consistency. The clouds and condensations appearing in the urine were designated according to whether they were situated on the surface, in the middle or on the bottom of the vessel, as *νεφέλη* (nubecula), *ἐναιώρημα* (suspensum) or *ὑπόστασις* (sedimentum). Uniform, clumpy, bran-like, lamelliform and scaly, sediments are described. Among the abnormally colored urines that which is black, thick, and offensive is considered especially dangerous. The writers point out significantly that the source of the abnormal constituents of the urine may be located in various parts of the urinary system. "One must not be deceived because the bladder itself is diseased and gives to the urine such characteristics, for that is not a general symptom good for the whole body but is only a special symptom of the bladder." If bubbles form on the urine, one may conclude that the disease is in the kidneys and that it will last a long time. Frothy urine associated with unconsciousness, diminished vision, points to approaching convulsions,—this is a good observation of uremic symptoms in chronic nephritis. Bloody urine is indicative of rupture of renal veins, inflammation of the kidneys, ulcers of the bladder, and of disease of the parts surrounding the bladder. "Bloody urine does not indicate anything serious if it occurs rarely and without fever and pain, but when it appears often and one of these other symptoms is present, then it is a dangerous sign." Pus in the urine is found in cases of pain in the bladder with fever, vesical stones, and nodules in the urethra. In diseases of the kidney, fleshy particles appear in the urine. In chronic catarrh of the bladder the sediment is branny. Sandy urine indicates stones. Itching in the "lower parts" (glans penis) implies sandy urine and the passage of small calculi.

In the *Corpus Hippocraticum*, acute and chronic catarrh of the bladder, inflammation of the urethra with a discharge of pus, periurethral and prostatic abscess, dysuria, stranguria, ischuria and vesical calculi are described. The diagnosis was made by palpation through the rectum. The catheter which is mentioned among the surgical instruments of the Hippocratic writers was apparently not employed in the search for stones in the bladder. Renal colic was diagnosed on the basis of pain radiating into the inguinal region and testicle, of alternation between urgency and retention of urine, and of the sandy character of the urinary sediment. The frequency of lithiasis was attributed to the drinking of clayey and sandy waters. Ab-

scesses in the kidney and neighboring parts, which might result from stone (with rupture into the bladder, abdominal cavity or intestine), were treated by nephrotomy as soon as a fullness was visible. Wounds of the bladder were looked upon as fatal.

In keeping with the oath of Aesculapius, the Hippocraticists did not cut for stone, but left this "to those who were skilled in the technique." It may therefore be assumed that there were in ancient Hellas, as well as in other countries, special cutters for stone. There is, however, in the Hippocratic writings an objective description of the gradual enlargement of stones and of the symptoms caused by them.

It was Erasistratus (about 300 B.C.), one of the great men of the Alexandrian school, who recommended the *S*-shaped catheter. Among the bronze catheters found in Pompeii there is, besides straight instruments, also one with a double curvature. Ammonius, an Alexandrian surgeon known as a lithotomist, invented an instrument with which one could crush large vesical stones when they could not be extracted through the usual incision.

The great work of Celsus, written in Latin and based on the work of the Hippocratic and Alexandrian schools, contains not a few references of importance for the history of urology. It appears that Celsus tried to determine on the basis of the different characters of the urine whether the disease was referable to the bladder, the kidneys or other organs. Bloody or purulent urine resulted from disease (ulcers) of the bladder or kidney. Those suffering from stone could be recognized by the following signs: The urine is voided with difficulty and in drops; occasionally it is passed involuntarily. It contains sand-like admixtures and at times bloody or purulent material. Some can only void in the upright posture; others only when lying down, and this is the case especially when the stone is large. Others can succeed best if they bend forward and lessen their pains by stretching the urethra. There is also a feeling of great heaviness, which is increased by running or by any movement. If the kidneys are diseased, then they are apt to be diseased for a long time. In treatment Celsus advises rest, attention to the bowels (enemas), hot sitz-baths, avoidance of cold beverages and foods, and especially abstinence from all salty, spicy and sour articles, and fruit. He recommends an abundance of water and the use of substances that act on the secretion of the urine. Several chapters deal with urinary difficulties and their treatment. Catheterization with the curved metal catheter and its indica-

tions both in the male and in the female sex are exhaustively discussed. Several sections are devoted to the treatment of patients with stone, the signs of gravel and of soft stones, and the treatment after the removal of the stone. The chapter on lithotomy is especially famous. The method described in this classical section was probably that taught in the Alexandrian schools and was in use for many centuries, indeed up to the time of the Renaissance. The principle of "deep" lithotomy is described by Celsus as follows: Exposure of the transition between the urethra and the bladder by means of an incision through the soft parts of the perineum; opening of the urethra and extraction of small stones through the wound, with eventual preliminary crushing of the stone. Celsus mentions an instrument recommended for lithotomy by the famous Alexandrian surgeon Meges.

Areteaus, who probably lived about the middle of the first century A.D., in connection with diseases of the bladder speaks of blood clots, stones, ulcers, and impaction of stones in the urethra. He advised that the stones should be pushed back with a catheter so that the urine could be voided. If that were not possible, the perineum and the neck of the bladder should be incised so that the stone could fall out and the urine flow again, even if there was danger of a permanent urinary fistula. He designates as diabetes that disease in which, the chief symptom being thirst, the beverages run through the body and solids are dissolved in the urine. Emaciation and collapse may occur. The causes are acute diseases or poisons. In the treatment he recommends among other measures the milk cure.

In the preserved fragments of the writings of Heliodorus, who practiced surgery in Rome under Emperor Trajan, it appears that it was customary in treating strictures of the urethra to introduce after the removal of the "proliferations" a bougie of paper containing a stilet of bronze or zinc, or the rib of a feather. In antiquity and even as late as the Renaissance, strictures of the urethra were attributed to fleshy growths in the canal, the result of ulceration. A partial or complete change in the canal led to dysuria, stranguria or ischuria. Excision of the fleshy growths was performed with a small stilet which was introduced into the canal so as to perforate the proliferations. The instrument was then given a circular turn. The detached masses would be expressed from the urethra with the finger or removed with a small forceps.

Rufus of Ephesus, who also lived in the time of Trajan, dedi-

cates a separate work to the diseases of the urinary organs (diseases of the bladder and kidneys), in which he speaks of hematuria, paralysis of the bladder, and vesical stones. He gives interesting observations on the methods of examination as well as on treatment. It is particularly noteworthy that he mentions bimanual exploration. The patient, who is in the recumbent posture, is requested to bend the legs back as far as possible. The finger of the left hand is then introduced as high up as possible into the rectum, while the other hand presses down on the suprapubic region until the hard body (stone) is found. Sometimes rectal examination will reveal instead of a hard body, soft swellings (hypertrophy of the prostate) and abscesses. Rufus employed no diuretics in inflammation of the kidney, at least not in the beginning; instead he used warm enemas. In inflammation of the bladder of males he advised against the introduction of the catheter and recommended instead a warm and mild treatment—compresses, baths, clysters, suppositories, and pressure in the region of the bladder. He based the diagnosis of suppuration in the kidney on the discharge of large quantities of pus in the urine and on intermittent fever.

The second greatest physician of antiquity, Galen, concerned himself very much with the diseases of the urinary tract. Difficult urinary secretion, according to Galen, had three degrees of intensity. Dysuria is the mildest form, stranguria is present when the urine is voided in drops, ischuria when no urine appears externally. The cause resides in obstruction of the urinary passages (by reason of very thick urine, coagulated blood or calculous concretions), in inflammation or paralysis of the bladder (because of dyscrasia or pathological new growths), or in the acidity of the urine (in consequence of changes in the blood), or in diseases of the kidney. Dysuria can occur in the absence of disease of the urinary organs. If retention has lasted a considerable time, Galen advises evacuation of the urine with an S-shaped catheter. Inflammations of the kidney are often of long duration; indeed they can persist throughout life. Stone in the kidney arises just as gouty deposits in the joints. Bladder stones are more frequent in children, especially boys. Vesical calculi may be adherent or free. When the stone drops in front of the internal orifice of the urethra it may produce a temporary retention. Galen, like Rufus, employed bimanual examination. His description of renal colic is similar to that of Hippocrates. For purposes of differential diagnosis between renal and intestinal colic he made use of laxatives. He attributed diabetes,

the essence of which he saw only in polyuria, to a loosening of the kidney structure. He designated as psora of the bladder a condition in which the urine had a thick, tough consistency and contained branny scales (chronic cystitis). In the therapy of urinary calculi and of gout he employed among other things the following: Ass's milk, wine with honey, myrrh, parsley, caraway, ammoniac and the powder found in sponges; against hematuria, alum; and against ischuria, apium.

The main work of Celius Aurelianus on acute and chronic diseases, supposed to have been written in the fifth century, deals quite exhaustively with infections of the urinary tract. The author evidently knew a variety of diseases of the bladder, such as tumor, retention, ulcer, induration, debility, paralysis, stone, hematuria and slow and difficult micturition. Stones in the bladder are accompanied by severe pain which radiates to the pubic arch, the umbilicus and the testicle. The diagnosis was made on the basis of subjective signs and the finding of sediment in the urine. A sound was also employed. In the treatment of diseases of the bladder, one must avoid irritating diuretics and must depend chiefly on external applications, injections through a catheter, dietetic regimen and drink-cures. "Nephritis" (*Passio renalis*) runs its course with fever, constipation, abdominal pains and vomiting and ends in a state of weakness and emaciation. The urine at times is oily or putrid; the inflammation may extend to the ureters. The causes of the condition are exposure to cold, the use of spicy foods, digestive disturbances, injuries (falls on the buttocks), and abuse of diuretics, such as cantharides. A special chapter is devoted to hematuria. The Compendium of Cassius Felix, composed in the fifth century, mentions among the causes of dropsy, hardening of the kidney (*renum saxietas*). In the treatment of painful conditions, injections into the bladder are recommended.

The Byzantine writers on diseases of the bladder and kidney largely follow Galen. It is interesting that Oribasius (fourth century) in his colossal compendium mentions among tumors one at the neck of the bladder and in the cavity of the organ. This in all probability has reference to hypertrophy of the prostate. In the work of Aetius (sixth century) there is a chapter on diseases of the urinary tract including stone formation in the kidney and bladder. Various dietetic and pharmaceutical remedies are recommended, but while lithotomy is mentioned, it is not described. In one of the chapters urethrotomy is advised in cases of impacted stone after attempts at extraction have failed. This

particular observation was recorded by Philagrius, who practiced in Saloniki about the middle of the fourth century [B.C.]. Alexander of Tralles felt justified in drawing conclusions as to the nature of the disease from the quantity and appearance of the urinary sediment. He employed diuretics to bring about elimination of the pathogenic agents. Alexander also endeavored to make the differential diagnosis between bladder and kidney diseases more precise and expressed the opinion that strangury usually points to disease in the bladder; if the urine contains pus, it is suggestive of the presence of ulcers in the bladder. If there is no pain or swelling in the region of the bladder and no retention, the disease has its seat in the ureters or the kidney. Suppurative inflammations of the kidney are characterized by fever, pains and chills. The patient experiences a sense of weight when lying on the healthy side and every effort increases the pain. An excellent description of renal colic is given. The differential diagnosis between vesical and renal diseases is based on the general character of the urine. Paul of Aegina (seventh century) discusses among other subjects the practice of catheterization and injections into the bladder. With regard to the latter he says, "As it is often necessary when the bladder is ulcerated to irrigate it, we make use of an ear syringe, as it is best by means of it to make the injection. If this is not possible, we attach to the catheter an ox bladder and make the injection." The description of the operation of cutting for stone given by Paul is the most exhaustive that is to be found in any Greek author. It is contained in the 60th chapter, book VI. The 45th chapter of book III of the *Epitome* deals with diseases of the kidney and with renal stones, renal colic and the symptoms of stone in the bladder.

While the authors of classical antiquity and the great Byzantine physicians just mentioned laid stress on the examination of the urine they did not fall into the error of ignoring the other symptoms. Yet it is to be noted that subsequently more and more prominence was given to uroscopy; in fact uroscopy became the actual basis of medical practice. Erasistratus and his followers had already taken occasion to mock those physicians who distinguished an altogether too great number of colors of the urine and drew diagnostic conclusions from them. "*Erasistratus et sectatores irridebant urinarum observatores et tinctores appellabant.*" A work of uroscopic nature was falsely attributed to Galen; it is probable that this pseudo-Galenic work was written by Magnus of Emesa.

A tremendous influence upon uroscopy was exercised by the writings of Theophilus (seventh century), who discussed particularly the color changes of the urine. He mentions no less than 17, and used them as well as the consistency, the opacity and the sediment for diagnostic and prognostic conclusions. Theophilus based himself on the view of Galen that the urine was secreted by the lower vena cava. He added, however, the hypothesis that the watery constituents of the urine might be present in the portal vein and might thence enter the lower vena cava through exceedingly fine capillary canals. One could from the character of the urine learn the condition of the blood as a whole and also the diseases of separate parts of the body.

The last prominent Byzantine physician, Joannes Actuarius, whose extant work on the urine was written in the 14th century, not only collated the observations of his predecessors, but subjected them to a severe critical examination and added to them knowledge obtained by many personal observations. The changes that the urine undergoes in the diseases of various organs is explained on the basis of "sympathy." Joannes distinguishes twenty colors of the urine, takes note of the sedimentum, of the suspensum and the nubecula and, after many special observations, draws his conclusions on the humoral basis of pathology. He used a vessel made of white glass, which was divided into gradations. The sedimentum occupies the four lowest markings, the suspensum (sublimia) the sixth, seventh and eighth, and the nubecula the tenth and eleventh. The fifth and ninth form the interspace between sedimentum and suspensum and between the latter and the nubecula (see figure 1). Joannes Actuarius, whose monograph consisted of seven books and subsequently became the basic work in uroscopy, contrary to the prevailing opinion did not attach to water-casting the value of a universal means of diagnosis, but emphasized the necessity of examining the pulse, the respiration, the sputum, the feces, etc. In general, it is stated, no single method suffices in arriving at a correct diagnosis and prognosis. Particularly was it necessary to supplement uroscopy with examination of the pulse. By means of the pulse one could determine the condition of the internal heat and of the vital force, while the urine indicated the quality and quantity of the humors, and the excreta the nature of the coction (digestion). The method of most value in a particular case depended on the nature of the disease.

In Arabian medicine urology occupies by no means an unimportant place. Rhazes in the twenty-third book of his

"al-Hawi" ("Continens") describes the origin, symptoms and treatment of vesical stones (lithotomy). Retention of urine can be produced through stone or through paralysis. If medicine has no effect, the catheter is to be employed. In the principal

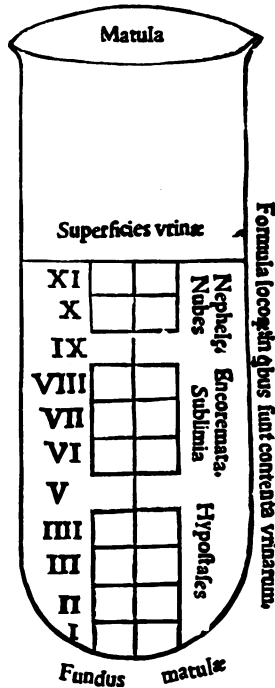


FIG. 1. Reproduced from the copy of the original edition (Venice, 1519) of Actuarius' "De urinis" in the library of the College of Physicians of Philadelphia.

work of Ali Abbas, "al-Maliki," there are a number of cases of diseases of the kidneys and bladder, including their treatment. The extraction of stones from the bladder is described after the manner of the ancients. Albucasis in his "Surgery," which is based principally upon the writings of the Greeks, especially upon the work of Paul of Aegina, discusses exhaustively the diseases of the urinary tract. The causes of retention of urine are given as follows: Stricture, stone, blood-clot, pus, fleshy excrescences (hypertrophy of the prostate). If other methods fail, catheterization must be employed. The catheter, made of silver, is to be anointed with oil, fresh butter, or egg albumen. For the injection of oil or other fluids into the bladder in ulceration or suppuration he used a syringe having a long cannula with three openings. In the description of lithotomy Albucasis is a

follower of Paul of Aegina, but makes certain not unimportant changes that indicate independent observation. He discusses very fully the crushing of the stone. There is also an interesting chapter concerning lithotomy in women, in which he indicates the difficulties that arise through oriental customs in the treatment of women by men in the region of the genitalia. Uroscopy itself is treated in an even more subtle and complicated manner, although Rhazes had already attacked the quackery that had developed in connection with uroscopy. Men had attained great wealth through purposely false water-casting. As an illustration he relates the case of the apothecary Abu Koreisch Isa who was made the personal physician of the Kalif al-Mahdi because he had predicted from the urine that the Kalif's wife would give birth to a son.

One of the most popular works on the urine was that of the Jewish physician Isaac ben Soleiman al-Israeli (ninth to tenth century). It is characterized by logical and clear descriptions. Isaac considers the semiotic of the urine of greatest importance because it gives information concerning the energy of the vital processes, of the vital heat and of the processes of coction (metabolism). The work of Isaac, translated into Latin, exercised the greatest influence upon Western medicine in the Middle Ages. Avicenna, the chief authority in Arabian medicine, places a subtle uroscopy in the very center of diagnostic methods.

In the oldest and most famous medical school of the occident, in Salerno, uroscopy was cultivated intensively through the influence of Arabian medicine. An increasing number of works appeared, nearly all basing themselves on the writings of Isaac Judaeus which had been translated into Latin by Constantine. Among them, to name just a few, are the "*Regulae urinarum*" of the younger Johannes Platearius, the work "*De urinis*" of Archimathaeus, the "*Compendium de urinis*" of Master Urso, in which color and density of the urine are employed in diagnosis and are particularly valued, the "*Regulae urinarum*" of Maurus (about 1160), containing a uroscopy based on Theophilus and Isaac Judaeus, as well as a special pathology. Maurus noted the color, the density, the quantity and the contenta (turbidity and sediment). He distinguishes nineteen colors of the urine (albus, lacteus, glaucus, caropus, subpallidus, pallidus, subcitrinus, citrinus, subrufus, rufus, subrubeus, rubeus, subrubicundus, rubicundus, inopos, kianos, viridis, lividus, niger). Just as in the human body, four regions could be differentiated in the urine. In consequence special diagnostic importance was at-

tached to the place in the urinary vessel in which change of color, clouding, etc., was observed. The four regions in which the body was divided were the head region (*membra animata*); the thorax (*membra spiritualia*), that is, the heart and lungs; the abdominal region (*membra nutritiva*), namely, the stomach, intestines, the liver, spleen, etc.; and the region of the genital organs (*membra generativa*), that is, in addition to the external genitalia, the kidneys, ureters and bladder.

The medical didactic poem of Gilles de Corbeil, who transplanted Salernitan medicine to Paris and who lived to the beginning of the thirteenth century, enjoyed the greatest respect as late as the sixteenth century. "*Liber de urinis*" is a compendium on uroscopy consisting of 352 hexameters. Many commentaries were written upon it. After a definition of the urine (*sanguinis serum*) the author discusses the points to be observed, namely, quality (color), density, contents (opacities and sediments), quantity, the place where the urine in the glass shows itself turbid, the time of micturition and of the examination, the age of the patient, temperament, sex, mode of life, and psychic state. This is followed by a discussion of the genesis and pathognomonic significance of the colors and the sediments of the urine. The poem of Gilles de Corbeil had many imitators and many prose and poetic excerpts were made from it; among others the "*Compendium urinarum*" of Gualtherus Agulinus (13th century).

Besides the very subtle examination of the pulse, uroscopy played a chief rôle in all medical fields during the later Middle Ages. It served to determine the complexion and the strength of the patient, the particular disturbance of function and its location, and the dyscrasia underlying the disease. Uroscopy presupposed the doctrine that the urine was a distillate of the blood formed in the liver and of the other cardinal juices derived from the metabolism or the second digestion in the liver. In consequence the belief prevailed that one could determine from the urine not only the state of the urine-forming organs and of the urinary tract, but also the processes of coction, the condition of the blood and other humors,—in other words, the state of health of the whole body. All diseases depending upon anomalies in the humors or connected in any way with the humors, which constituted the largest part of pathology, were the domain of uroscopy. While the pulse was principally of value in prognosis the urine facilitated diagnosis. Manuscripts of the fourteenth and fifteenth centuries contain colored illustrations indicating the

significance of uroscopy in so far as it was based on the color of the urine. These illustrations depict the so-called urinary discs, water-casting discs or water-glass tables. Figure 2 is an exam-

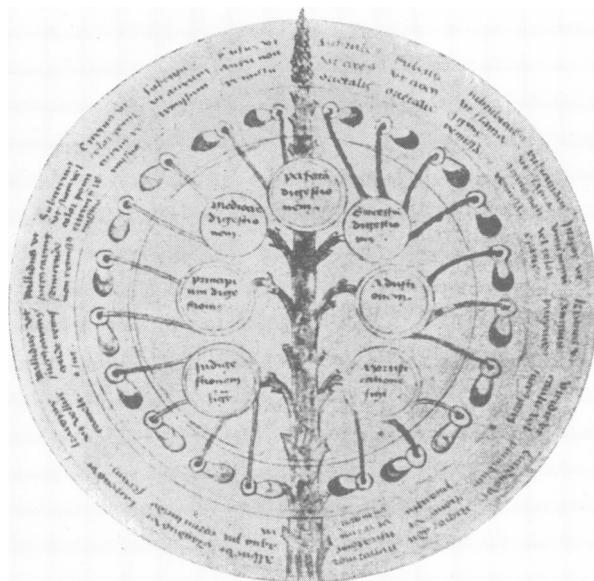


FIG. 2. (Codex lat. 11229. Bibliothèque Nationale.) Reproduced from the author's original article in the *Wiener klinische Wochenschrift*, 1936, Nr. 37/38.

ple of such a disc preserved in the Cod. lat. 11229, of the Bibliothèque Nationale in Paris (c. 1400). The illustration shows a central tree surrounded by seven circular discs, and around these in a circle twenty urine vessels, each with correspondingly colored contents, and the legend at the periphery. The types of urine discs and their accompanying texts differ considerably in the various manuscripts. The color of the urine gave information as to the predominance of one of the four qualities or cardinal humors or, as may be seen in the legends, of the degree of coction of the juices.

The importance of uroscopy in the Middle Ages may be inferred from the many works of art in which the physician is shown with a urine glass in his hand, even in the representations of the medical saints, St. Cosmas and St. Damian (Fig. 3). The urine glass is the chief symbol of the medical art. In fact, the urine glass has become a part of the escutcheon of the medical guild. Even in the non-medical literature of the period uroscopy plays a not inconsiderable rôle, and much later Shake-

speare ranks "the monarch of the urine" as co-equal with the physician ("Merry Wives," II, 3).

Just as in the age of Hippocrates there were empiric lithotomists, so there were in Italy many special cutters for stone. The

Cosmas vñ Damianus



FIG. 3. Reproduced from the copy of the "Nuremberg chronicle," 1493 (German text), in the library of the College of Physicians of Philadelphia.

most famous of these belonged to certain families of Norcia in Umbria and vicinity, particularly the Castello and Contado delle Preci. During a long series of generations the Norcians and Precians practiced lithotomy, herniotomy and cataract operations. In other countries travelling empirics performed lithotomy, the local surgeons declining to operate on account of the danger of the operation. There is no contradiction to this in the fact that the principal works of surgical writers of the Middle Ages devoted extensive chapters to the diseases of the urinary tract. The writings are for the most part based on literary tradition, but here and there one finds a considerable number of practical innovations. Even the greatest surgical author of the fourteenth century, Guy de Chauliac, says that he never performed lithotomy as other "periti" did. He leaves this to peripatetic lithotomists. In a section on renal and vesical stone he states that in the diagnosis the introduction of the finger into the rectum is not sufficient, but that a catheter should also be used. Before discussing lithotomy he mentions a number of

internal measures, also baths, compresses, plasters, inunctions in the suprapubic and perineal regions and penis, as well as injections into the bladder in order to increase the secretion of urine. Catheterization is exhaustively discussed, but the description of lithotomy is very brief and based on Celsus and Paulus.

The progress that occurred in medicine during the course of the sixteenth century, largely as the result of the rediscovery or rebirth of antique art and science, and which led to the awakening of independent observation, is clearly revealed in the urology of the period. Definite improvement, even if only in traces, is recognizable in the anatomic knowledge of the urinary organs. There is likewise a broadening of the general concept of disease, which redounded to the great advantage of surgical urology. Eustachius concerned himself with the structure of the kidney and describes in his "*De renibus libellus*" the tubes, later called the tubes of Bellini. In order to learn something of the formation of the urine he injected water into the renal artery. Contrary to the teaching of the ancients that wounds of the kidney are absolutely fatal, Falloppius reports cases of cure. Franciscus de Pedemontium was the first author to mention movable kidney. In the same century we find the first observations on conditions that were undoubtedly hydronephrosis. Bauhin and Plater described a recovery from wounds of the bladder.

The technique of lithotomy was much improved in the sixteenth century. The usual method, described by Celsus and by Paulus of Aegina, was modified so that prior to the operation a curved hollow catheter was introduced, with its convexity toward the perineum, into the urethra. Since the incision in the pars membranacea was made in the groove of this sound, the operator's hand had a sure guide. Because so many instruments were required for it, this procedure was called "the procedure with the large instrumentarium." Although the inventor was Bernardo di Rapallo, the operation was generally called after the name of Mariano Santo. The disadvantage of perineal lithotomy, namely that it often led to suppuration in the prostate and the mouth of the seminal vessels, with consequent impotence, and the inability to remove large or incapsulated stones, suggested the thought that it might be possible to remove the stone through an incision above the pubis. Pierre Franco was the first (1560) to execute superior lithotomy. Later Rousset suggested that the bladder be filled with water before the operation is undertaken. Franco, recognizing that the high incision involved many risks, returned again to perineal lithotomy, but

under a new method, namely, the *sectio lateralis*, that is, left-sided perineal lithotomy through the prostate and the neck of the bladder without opening the bladder directly. It is interesting that Franco also made the suggestion of a two-stage lithotomy in cases in which the extraction of the stone was difficult or the patient's strength greatly reduced. With regard to vesical stones in the female sex, he called attention to the fact that they could at times be easily extracted by simply enlarging the diameter of the urethra. According to Benedetti a number of surgeons crushed the stone with iron instruments without making any incision. The operative cure of strictures of the urethra by means of the knife, an operation already practiced by the surgeons of the Roman Empire, was revived by Ambroise Paré, who used an instrument resembling the urethrotome. Bougies anointed with medicaments were also used in stricture, being particularly recommended by Laguna.

Although in the last centuries of the Middle Ages voices had been raised against uroscopy, for example those of Petrarch in the 14th century, Johann Geiler of Strassburg in the 15th century, the movement grew in the age of humanism. Among the opponents of uroscopy should be mentioned Bishop Dudith von Horekowicz, the physician Clementius Clementinus, Christoph Clauser in Zurich, Franz Emmerich in Vienna, Bruno Seidel in Erfurt, Adolph Scribonius in Marburg, Johann Lange, physician to the Elector-Palatine, Sigmund Koelreuter and Leonardo Botallo, the last one of the most famous practitioners of his time. The most vehement opponent of uroscopy, by this time degenerated into uromanty, was Petrus Forestus, as appears in his book "*De incerto fallaci urinarum judicio*." Euricius Cordus appealed to the Magistracy of the City of Breslau to inform the public that it was not possible to recognize diseases by inspecting the urine. It was, however, not possible to abolish uroscopy and uromanty so easily and the nimbus that surrounded a physician who was able by a mere inspection of the urine to make a diagnosis was so great that physicians who found that they needed additional means for examining a patient were not rarely held in low esteem. Moreover, there were a number of medical authorities who during the course of the 16th and 17th centuries endeavored to re-establish uroscopy. Numerous works of this period contain detailed rules concerning the art of water-casting, as for example the writings of Jean Vassès, Davach de la Rivière and others. Robert Fludd, a contemporary of Bacon and Harvey, went so far as to write two tracts on uromanty in which

diagnosis and treatment are based on the planets and on astrological investigation after inspection or even after a mere description of the urine.

Nevertheless, attempts were made in the 16th and at the beginning of the 17th century to replace uroscopy by chemical and physical methods. Even in an earlier period Nicolaus Cusanus proposed that the scales be made a mathematical basis in medicine. "Just as by the use of the water-clock, that is, by determining the weight of water, it was possible to arrive at a better understanding of the quality of the pulse than through mere palpation, and as it was possible to measure the depth of breathing in the same way, so the quality of the urine could be better determined by weight than by simple inspection as was the general practice." Cusanus and Leonhard Thurneysser, a follower of Paracelsus, and van Helmont, the most important successor of Paracelsus, determined the relative weight of the urine. The instrument used to ascertain the specific gravity, called hydrometrum, was very similar to the ureometer used at the present day.

Microscopic examinations of the urine were first made by Alphonso Borelli (17th century). The application of chemistry to medicine initiated by Paracelsus led in the field with which we are concerned to the so-called Spagyric Urology, a process of distillation employed especially by Thurneysser, who distinguished a vaporous or volatile, a watery and a mineral substance in the urine.

Real chemical examination was inaugurated by Bellini, in whose works we find the first beginnings of a scientific analysis. Bellini at the early age of 19 published his famous book, "*De structura et usu renum*" (Florence, 1662) in which he spoke of the kidney as in the main a conglomerate of tubules, the so-called "Bellini tubules," and in which he gave fairly correct views regarding the physiology of renal activity. He defines the urine as an excrementitious fluid secreted from the blood by the kidneys, whence it reaches the bladder by way of the ureters. He considered it an axiom to compare the urine of the patient with normal urine. His methods of examination did not include distillation; he heated the urine and noted changes in color, consistency and transparency. After partial evaporation, a liquid analogous to the original urine was produced by the addition of water. The consistency of the urine depended on the relation between its liquid and solid substances. Bellini also emphasized the importance of the specific gravity of the urine. One of the

most valuable contributions on urine diagnosis was made by the Leyden professor, Fridericus Dekkers, who in 1694 was the first to perform the heat test for albumin with the addition of acetic acid. In his work, "*Exercitationes practicae*," he states that the urine of certain patients becomes turbid on boiling and that on the addition of acetic acid a flocculent precipitate falls to the bottom. It was the great English physician Thomas Willis who, in his treatise, "*De medicamentorum operationibus*" (*Opera omnia*, Geneva, 1676, liber IV, cap. 3), made the statement that the urine of diabetics was remarkably sweet, just like honey or sugar. He did not realize that this sweetness was actually produced by sugar. It is noteworthy that Willis treated diabetic patients almost exclusively with either undiluted or diluted milk, or with barley, which was taken several times a day.

During the 18th century the lateral incision for stone became the most popular method of lithotomy. In the history of this method Frère Jacques (Beaulieu), Rau, Cheselden and Morand played an important rôle. Among the modifications which later were made, that of Frère Côme is especially noteworthy. He recommended the hidden lithotome for the operation. However, the *sectio alta*, the suprapubic operation, was also revived, various modifications being made by MacGill, Douglas, Cheselden and Morand. Progress in our knowledge of the etiology and anatomy of stricture of the urethra is largely due to John Hunter. Hunter limited himself, in all cases in which the introduction of a bougie was possible, to the mechanical method of treatment. Where this failed, he employed repeated cauterization with silver nitrate. In opposition to Hunter, Desault resorted to cauterization only in the rarest cases. He also rejected the so-called "medicamental" bougies recommended by Daran. His method in the average case of stricture consisted in permanent dilatation by means of an elastic catheter.

The widespread interest in the chemistry of the urine led in the 18th century to the discovery of several normal and pathological urine-constituents. It was the great clinician Boerhaave who gave particular attention to the examination of the urine. He published the fifth edition of Bellini's work on the urine and continued the latter's chemical investigations. Boerhaave invented a method for the determination of the specific gravity of the urine. In a work on sciatica by Domenico Cotugno, published in 1764, we find the important discovery of a substance coagulated by heat in the urine of dropsical patients. We have

already mentioned, however, that the heat test of the urine for albumin with the drop-by-drop addition of acid really goes back to Dekkers. It became customary about this time, following a suggestion of Cruikshank, to divide the dropsical cases into those with and those without albumin in the urine.

Pathologic studies (Bonet, Morgagni) demonstrated with a high degree of probability the relation between ascites and changes in the kidney, a relation already conjectured by Hippocrates, Galen, Aetius, Avicenna, and William of Saliceto.

The chemistry of the decomposition of the urine, recognized as a striking sign of cystitis, gave rise to numerous investigations beginning with those of Boerhaave and continued by Rouelle the younger and by Cruikshank. They were brought to a certain degree of completion by Fourcroy and Vauquelin when they in 1799 isolated urea and demonstrated its decomposition with the formation of ammonia. Scheele in 1770 [1776] discovered uric acid. The study of diabetes was markedly advanced about one hundred years after Willis by Dobson, who in 1774 proved that the urine of all diabetic persons tasted sweet and that it showed vinous and acetic fermentation, that the blood serum also had a sweet taste, that the urine on evaporation under heat deposited a white precipitate. The taste of this precipitate was similar to that of brown sugar. However, his ideas regarding sugar did not receive acceptance until about 1800, following the researches of Home, Cowley and Rollo. Johann Peter Frank was the first to produce sugar in crystal form by chemical means.

The first decades of the nineteenth century are characterized by noteworthy advances in the domain of the chemistry of the urine and in those of the pathology of the urinary tract and the surgical technique. As far as the chemistry is concerned the synthetic preparation of urea by Woehler (1828) was of the greatest significance. After Alison, as early as 1823, had asserted that in several cases of dropsy with albuminous urine he had found hard granular kidneys, Bright in a series of essays, the first of which appeared in 1827, stated with positiveness that many cases of dropsy depended on disease of the kidneys and that this showed itself in the presence of albumin in the urine. The further investigation of these diseases of the kidney, which was favored by the rapidly developing microscopic and chemical methods of examination, gave a secure basis to pathology. The first large monograph on all the diseases of the kidney was published by Rayer (1839-1841). The first attempts to make the urethra visible to the eye were made by the Frankfort physician,

Bozzini. Segalas in 1826 constructed an improved urethro-cystic speculum based on new principles and the American John Fisher in 1827 described a complicated instrument for illuminating dark cavities. The first impulse to refine the almost forgotten lithotripsy was given in 1813 by Gruithuisen in Munich, but his instruments were not suitable for crushing the stone and did not serve their purpose. Among those who invented more appropriate instruments and also made experiments on the cadaver, Fournier, Amussat and Leroy d'Etiolles should be mentioned. Civiale (1824) with his litholabe was the first who succeeded in the living patient. Further development resulted from the invention of the percuter by Heurteloup. It is to Félix Guyon that the credit belongs for establishing the symptomatology of the diseases of the urinary tract on a definite basis; while the development of the correct methods for diagnosis is the immortal achievement of Max Nitze.